APPENDIX A

TRAFFIC DATA PROCEDURES AND ANALYSIS

INTRODUCTION

Generally ADOT can provide or determine traffic loading information in 18 kip ESAL's on all state highways under ADOT jurisdiction. The following procedure describes how ADOT developes these traffic loadings.

SOURCES OF TRAFFIC DATA

The Transportation Planning Division (TPD) is responsible for the collection and the publication of traffic data. There are three types of traffic data which must be collected to determine the traffic loading.

1. TRAFFIC VOLUME

The TPD has Automatic Traffic Recording (ATR) devices that obtain samples from 983 locations. These data are published annually in the "Traffic on Arizona Highway System Logbook".

The Materials Section maintains a computer file containing the last ten years of traffic volume data from which traffic volume and growth factors are calculated using regression analysis.

2. TRAFFIC CLASSIFICATION

Samples of the traffic mix are collected annually at 129 locations. This operation has been done by a manual count of the number of vehicles in each of the following categories:

	Abbreviation
* Light Trucks	LT
* Medium Trucks	MT
* Tractor Semi-trailer	TS
* Tractor Trailer	TT
* Tractor Semi-trailer Trailer	TST
* Buses	
* Automobiles	

The "commercial vehicles" include the first five vehicle categories shown above.

A five-year moving average of classification data is used to estimate the percentage distribution among the vehicle categories.

Figure A-1 shows the typical configuration of each of these vehicles types and their grouping into one of the general categories shown above.

3. TRAFFIC WEIGHT

Every other year the TPD conducts a Truck Weight Study (also called a loadometer study) which is a sample of the axle weights of 13 vehicle types. These data are sent to Washington, D.C. where a computer program generates a report consisting of six tables of data, labelled W-2 through W-7. The W-4 table contains the information needed to develop the representative 18 Kip ESAL's for each vehicle category. The calculation of vehicle equivalencies is based on regression analysis performed on the data from the last six Truck Weight Studies. The equivalencies of the TS, TT, and TST vehicle classes increase with time. The equivalency equations in effect for 1988 for these vehicles are:

Flexible Pavements @ 110 PSI Tire Pressures

$$TS = -0.98126 + 0.02771 * YR$$
$$TT = -0.22238 + 0.02041 * YR$$
$$TST = -1.44956 + 0.04182 * YR$$

Rigid Pavements @ 110 PSI Tire Pressures

$$TS = -1.62774 + 0.03750 * YR$$
$$TT = -0.85942 + 0.026655 * YR$$
$$TST = -1.83450 + 0.041815 * YR$$

where these AASHTO parameters hold:

$Pt = 2.5$
$SN = 5.0$ for Flexible Pavements
$D = 9.0$ for Rigid Pavements

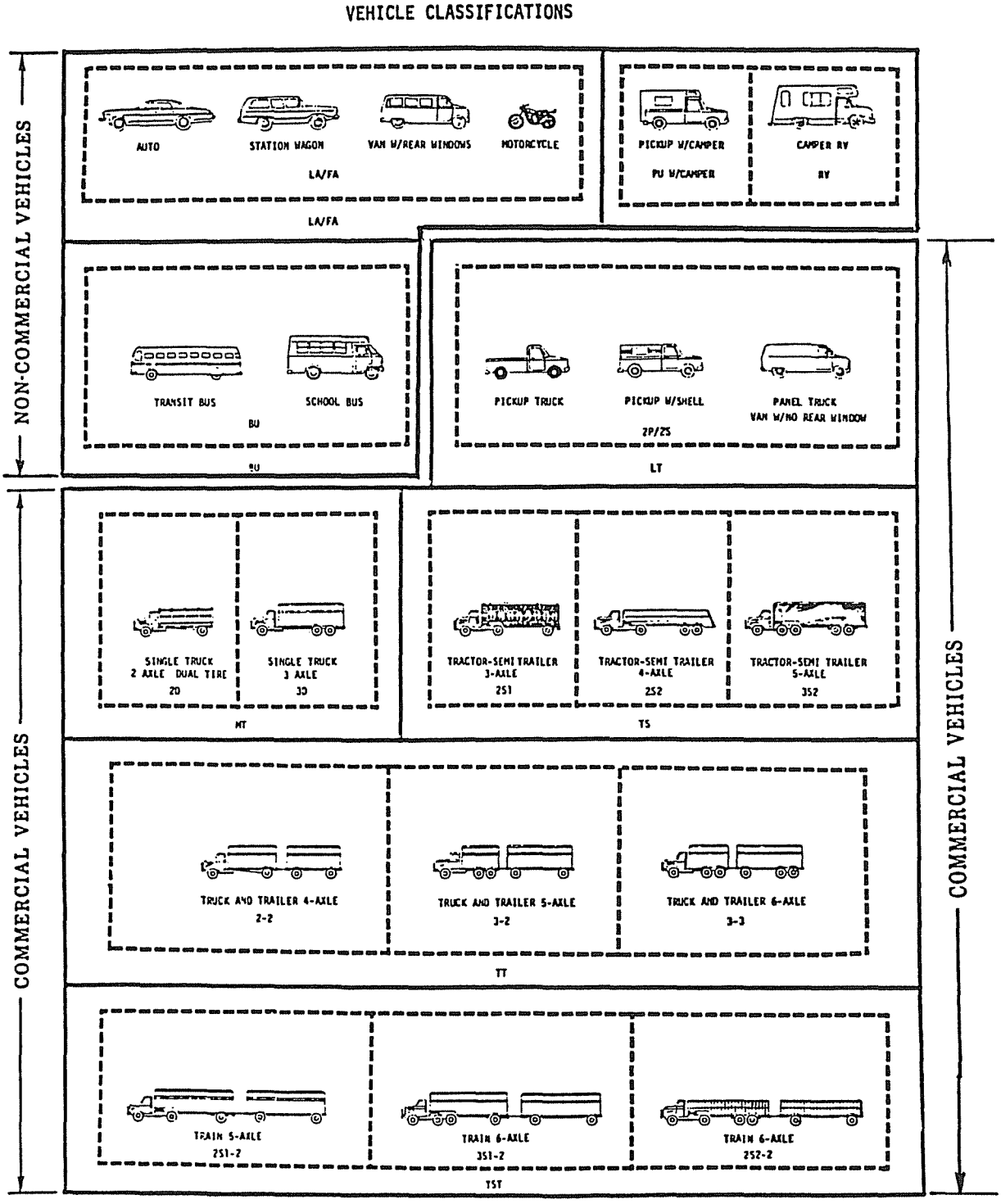
and

$YR = YEAR - 1900$

YEAR is the mid-year of the design analysis (performance) period. For example, for a 20 year pavement design from 1987 to 2008, YEAR = 1998 and

$YR = 1998 - 1900$
$= 98$

FIGURE A-1


VEHICLE CLASSIFICATIONS
NON-COMMERCIAL VEHICLES
COMMERCIAL VEHICLES
AUTO
STATION WAGON
VAN W/REAR WINDOWS
MOTORCYCLE
LA/FA
LA/FA
PICKUP W/CAMPER
CAMPER RV
PU W/CAMPER
RV
TRANSIT BUS
SCHOOL BUS
BU
BU
PICKUP TRUCK
PICKUP W/SHELL
PANEL TRUCK
VAN W/NO REAR WINDOW
2P/2S
LT
SINGLE TRUCK
2 AXLE DUAL TIRE
2D
SINGLE TRUCK
3 AXLE
3D
MT
TRACTOR-SEMI TRAILER
3-AXLE
2S1
TRACTOR-SEMI TRAILER
4-AXLE
2S2
TRACTOR-SEMI TRAILER
5-AXLE
3S2
TS
TRUCK AND TRAILER 4-AXLE
2-2
TRUCK AND TRAILER 5-AXLE
3-2
TRUCK AND TRAILER 6-AXLE
3-3
TT
TRAIN 5-AXLE
2S1-2
TRAIN 6-AXLE
3S1-2
TRAIN 6-AXLE
2S2-2
TST

The other four vehicle classification equivalencies do not change with time or with pavement type, they are:

Automobiles	=	0.0008
Buses	=	0.2500
LT	=	0.0100
MT	=	0.4000

The three heavy vehicle equivalencies have been calculated and are tabulated in Table A-1.

By multiplying the traffic loading factors for each vehicle type by the number of vehicles of each type over the design period and summing it is possible to find the cumulative number of 18 kip ESAL's. However, it may be necessary to use an approximation to estimate design traffic loadings (TTL) when vehicle classification data is not available in sufficient detail to use the seven vehicle equivalencies employed by ADOT.

This method requires:

A. An estimate of the number of heavy trucks (TS, TT, and TST) for the design period.

B. An estimate of the relative loads of the heavy trucks based on these guidelines:

   Heavy - Similar to interstate truck loadings.

   Medium - Similar to a US highway.

   Light - Similar to a state secondary highway or urban highway.

C. Assign equivalencies based on the category of truck loading chosen:

   Heavy = 1.2

   Medium = 1.0

   Light = 0.8

D. Multiply the total number of heavy trucks expected during the design period times the equivalencies to obtain the design 18 kip ESAL's.

TABLE A-1

HEAVY VEHICLE EQUIVALENCIES 1987-1997

RIGID PAVEMENTS

YEAR	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
YR	88	89	90	91	92	93	94	95	96	97	98
TS	1.6723	1.7098	1.7473	1.7848	1.8223	1.8598	1.8973	1.9348	1.9723	2.0098	2.0473
TT	1.4862	1.5129	1.5395	1.5662	1.5928	1.6195	1.6461	1.6728	1.6995	1.7261	1.7528
TST	1.8452	1.8870	1.9289	1.9707	2.0125	2.0543	2.0961	2.1379	2.1797	2.2216	2.2634

FLEXIBLE PAVEMENTS

YEAR	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
YR	88	89	90	91	92	93	94	95	96	97	98
TS	1.4572	1.4849	1.5126	1.5403	1.5681	1.5958	1.6235	1.6512	1.6789	1.7066	1.7343
TT	1.5737	1.5941	1.6145	1.6349	1.6553	1.6757	1.6962	1.7166	1.7370	1.7574	1.7778
TST	2.2306	2.2724	2.3142	2.3561	2.3979	2.4397	2.4815	2.5233	2.5652	2.6070	2.6488

4. TRAFFIC DATA COLLECTION IMPROVEMENTS

A. Weigh-In-Motion (WIM) Study

The TPD has two WIM devices that automatically sense the dynamic weight of moving axles, estimate vehicle velocity, and classify vehicles by type. This method may be implemented in the future to replace static weighing procedures.

B. Ports of Entry (POE) Data

There are 14 POE locations in Arizona which regularly weigh commercial vehicles. The weight data are collected and recorded manually by the Motor Vehicle Division (MVD). The present procedures do not offer a convenient means of utilizing the POE truck weight data for traffic loading estimates. Recommendations have been made to the MVD to automate the scales and the truck weight data management. These data could then be included with the other truck weight data to increase sample size and improve the quality of the traffic loading estimates.

APPENDIX B

PAVEMENT DESIGN FOR FROST ACTION

Depth of frost penetration is related to the freezing index. Figure B-1 shows Arizona freezing index values representing the average of the four coldest winters between 1931 and 1970. This figure should be used to estimate the depth of frost penetration using the following formula.

$$D_F = (FI)^{0.5}$$

D_F = Depth of frost penetration in inches

FI = Freezing index from Figure B-1

For purposes of pavement design all highways constructed within an area of the state with some freezing index shall consist of non-frost susceptible materials. These materials include pavement, bound bases and unbound base with no more than six (6) percent passing the number 200 sieve.

If the depth of frost penetration is greater than the required pavement structural section (pavement plus base), then additional non-frost susceptible base should be included to prevent frost damage.

If other constraints such as utilities, drainage, traffic access, etc., prohibit the construction of a completely frost free structural section, then the thickest section practical should be built.

FIGURE B-1

FREEZING INDEX